on the relations between sun spots and rainfall, based upon a study of the lines in the spectrum of sun spots and of the rainfall data of India, which may be summarized as follows:

(1) The sun is warmest at sun-spot maximum and coolest at sun-spot minimum.

(2) In India there is a maximum of rainfall at about the time of sun-spot maximum, and a secondary maximum at about the time of sun-spot minimum. In Mauritius there is a maximum of rainfall at the time of minimum sun spots.

(3) The dates of the beginning of the pulses in the rainfall of India and the Mauritius are related to the sudden remarkable changes in the behavior of the widened lines in the spectrum of sun spots.

(4) All the famines that have devastated India during the last half century have occurred in the intervals between the two pulses.

(5) Important variations are found in (1) the widened lines, (2) the rainfall of India, and (3) the Mauritius in connection with the maximum of 1893 as compared with the maximum of 1883; but the minimum of 1888–89 resembles the previous minimum of 1878–79.

(6) The lowest stages of the Nile have occurred between the same intervals as the Indian famines.

(7) The relation of the intervals in question to the droughts of Australia and Cape Colony and to the variations in rainfall in extra-tropical regions generally has not yet been investigated.

(8) Mr. John Eliot states that these deductions accord closely with the known facts of the abnormal features of the rainfall, temperature, and pressure of India during the past twenty-five years, and will be of great service in forecasting future famines.

At the time of maximum sun spots many of the widened lines of the spectrum of the spots can not be identified by means of charts of the lines of the solar spectrum, perhaps because they are enhanced, or high temperature lines. At any rate, the coincidence in the time of the occurrence of the maximum of sun spots and the maximum of these unknown lines, together with the increase in the number of eruptive prominences in the lower latitudes of the sun, is considered evidence that at this time the solar temperature reaches a maximum. The known lines of sun-spot spectrum reach a maximum when sun spots and eruptive prominences are at a minimum and when the solar heat is also supposed to be at a minimum. The curves representing the frequency of the known and unknown lines are very much flattened at the time of their maximum and minimum phases, and at some intermediate point they cross at quite a sharp angle. It is after these crossings, when either the known or unknown lines are on the increase, that the rainfall pulses have occurred, and it is previous to this, when the number of known and unknown lines is not changing perceptibly, that the Indian famines have occurred.

Ordinarily the crossings occur every five or six years, or twice during each 11-year cycle, as will be seen from the following table, which also shows the relation between the rainfall pulses for India and such crossings as have occurred since the known and unknown lines have been carefully observed and plotted.

	Years.			
Crossings	1881	1886	1892	
Rain pulses	1881–84	1887–90	1892–94	
Indian famines	1879–81	1884–86	1890–92	1896–97, 1899

The crossing that we would expect in 1897 has not yet occurred, showing that the interval between crossings is by no means regular. But the unprecedented famine of 1899 accords with the theory that the rain pulses commence at about the time of a crossing of the known and unknown lines and are of limited duration, and that in consequence famines may be expected during the years just preceding a crossing, and will be especially severe whenever the crossings are delayed.

A popular presentation of these facts, by Sir Norman Lockyer, in the North American Review for June, 1901, appears to have attracted a great deal of attention, and some inquiries and many clippings on the subject have found their way to the Weather Bureau. As is so often the case, many of the newspaper correspondents appear to have misunderstood the real object of these scientific investigations, which was, as stated by the Lockyers, to see if sun spots would aid in predicting the occurrence of famines in India. Except in a few cases they have not been able to study the relations between the crossings of the known and unknown lines of the spectrum of sun spots and the rainfall outside of India. In the valleys of the Nile and the Mississippi rivers they found evidence of rain pulses such as occur in India, while at other places no such pulses could be detected. Evidently, therefore, it is claiming too much, and certainly more than the Lockyers intended, to say that any general relation between sun spots, temperature, and rainfall, has been discovered that will apply to all regions of the globe. Neither are the claims that have been advanced by others consistent, since in one case we find the excessive heat of the summer of 1900 attributed to the general absence of sun spots, while in another case the absence of these spots is advanced as an indication of a cool, wet summer for this year.

That a very conservative attitude is maintained by Weather Bureau officials toward this question, is indicated by the following reply by the Chief of Bureau, dated June 13, 1901, to a letter from Maj. Henry Hammond, Beech Island, S. C., inquiring if the cold and wet weather of that section during the present season can be attributed to the 11-year sun-spot cycle:

June 21, 1901.

DEAR SIR: * * * I beg to advise you that the only relation between sun spots and terrestrial weather that appears to be definitely fixed is an increase in the number and violence of magnetic storms corresponding to years of maximum sun spots. No connection has thus far been shown between the spottedness of the sun and the fall of rain on this planet.

The low temperatures and the preponderance of rain in the South Atlantic States are due mainly to the paths taken by areas of low pressure moving across the United States from west to east. If in winter and spring these traveling areas of low pressure take a southerly course or move from the Gulf northeastwardly over the South Atlantic States, the weather will be cold and showery. If, on the other hand, the pressure is such that areas of high pressure move southeastwardly from the Lake region and lodge off the South Atlantic States, forming a semipermanent high in that region, warm, pleasant weather will result. During the month of May and thus far during June pressure has been remarkably low over the South Atlantic States, and there has been a relatively large number of rainy days. This condition is not a permanent one. In the ordinary course of events it should give way to the normal conditions for the season and the latitude.

AN INSTANCE OF BALL LIGHTNING AT SEA.

By ROBERT SEYBOTH, U. S. Weather Bureau.

The description in a local paper of a recent display of ball lightning near Cumberland, Md., has induced the present writer to relate his personal experience with this rare phenomenon, of whose strange vagaries no satisfactory explanation has as yet been offered, and the actual occurrence of which has sometimes been doubted. It is indeed difficult to formulate a theory that will cover all the peculiar manifestations attributed to ball lightning, especially as regards shape, color, slow and erratic movement, and, finally, explosive effects.

But whether all its visual manifestations are physical realities, or whether they are partly the result of an optical illu-

sion, the occurrence and destructive effects of ball lightning can not be doubted, as has been attested by numerous witnesses, and made unpleasantly patent to the writer of the following narrative.

The summer of 1867 found me, then a mere boy, aboard the New Bedford whaling bark *Orray Taft*, outbound from the desolate harbor of Marble Island, in the northwestern corner of Hudson Bay, where the vessel had wintered in the ice from September until June, and whence she had resumed her cruise in Arctic waters after "blubber and bone." On the night of June 30 to July 1 the bark encountered a genuine hurricane, with the (for the latitude) unusual phenomenon of a violent thunderstorm. A rock-bound lee shore and the presence of floe ice in large quantities, with an occasional berg, necessitated the carrying of all the sail possible, in order to "claw off" from the rocks on the one hand, and steer clear of the madly heaving and tumbling ice masses on the other. At about 2 a. m. wind and rain ceased with startling suddenness, and the sky showed signs of clearing, though a portentous cumulus cloud or "thunderhead" still hung low over the troubled waters.

The sudden cessation of the uproar, together with the violent pitching and rolling of the ship, brought the captain to the companion hatch, whence he shouted the emphatic order "Stand by to wear ship," adding, somewhat profanely, "We'll catch h— presently from the opposite quarter." Inured as the crew of a whaler is sure to become to unusual and critical situations, and apathetic as the writer felt to the peril of the present one, he nevertheless had a distinctly uncanny sensation at this sudden transition from howling hurricane to dead calm, associated with a large degree of skepticism at the captain's assurance in predicting and preparing for a still more violent change to come; for he had never before passed through the center of a cyclone, and his theoretical knowledge of the laws of storms was decidedly limited. But the man or boy who, aboard a whaler, would let skepticism stand in the way of his prompt compliance with an order from the captain would find his berth an exceedingly unhealthy one, and would most likely have cause to regret the day of his birth; so all hands rushed to their proper stations, to "stand by and haul," as and when directed. Happening to secure the upper hold on the fore-topsail brace, the writer facing sternward, again noticed the evil-looking thunderhead apparently but a few yards above the mizzen truck, and, while waiting in silent expectancy for the things to come, saw a ball of fire, the size of a man's head, detach itself from the cloud and sail quite leisurely to the mizzen truck, striking which it exploded with a deafening crash and sent a shower of hissing sparks over rigging and deck.

Of the immediate consequences, save one, the writer can only speak from hearsay. When he regained consciousness, he found himself sitting, propped up against the weather side of the mainmast, paralyzed in the right half of his body, and his shipmates busily engaged, some in clearing away the wreckage of the shattered mizzenmast, others in sounding the pump to discover whether or not the bolt had knocked a hole in the vessel's bottom. The latter calamity was probably averted by the fact that the lightning had found an easier escape to the water by way of the anchor chains through the hawsepipes, as both anchors had been made ready to let drop in case of the vessel's inability to weather the rocks. The one exception above noted, and which he has accepted as a proof that the velocity of thought is greater than that of lightning, was his distinct realization, at the critical moment, that he had been struck by lightning and was being hurled to the deck, though consciousness failed him before he struck it. He also had time to formulate the thought, "Well, it is all over with you this time," and feel rather gratified at the supposed fact. There was absolutely no pain felt, not even an unpleasant sensation; on the contrary, he seemed to sink into an agreeably restful position, though, according to his shipmates' statements, he was hurled with great violence into the lee scuppers. Of the other men on deck, especially those having hold of the brace, every one was more or less shocked, but none were rendered insensible. The writer's uppermost hold on the rope had evidently deflected the greater part of the charge through his body. The paralysis of his right side was gradually succeeded by a prickling, tingling sensation, and the movement of his limbs had again become possible by the time the watch was told to go below. His former skepticism of the captain's prognostication had to be atoned for by a mental apology, for the hurricane began with increased fury, and from the opposite quarter, almost immediately after the lightning had struck the mast.

One rather amusing story was told of the third mate, whose station in wearing ship was forward of the windlass. Standing inside of a big coil of the anchor chain, along which the lightning flew so that it looked like a huge fiery serpent, the mate was said to have been swiftly turned around his own axis a number of times, looking more like a dancing dervish than a grim old tar, while the lightning followed the convolutions of the coil. When he had regained his breath, the profanity of the veteran whaleman was said to have bordered on the sublime.

At a later period, while in charge of the newly-established Signal Service station on the summit of Pikes Peak, the writer had ample opportunity to familiarize himself with many different manifestations of atmospheric electricity, but never again has he witnessed that mysterious and weird phenomenon known as ball lightning.

THE CLIMATE OF HARPOOT, TURKEY, IN ASIA.

By Prof. ELLSWORTH HUNTINGTON, Euphrates College, Harpoot, dated April 13, 1901.

The accompanying tables[1] show the climatic conditions of Harpoot, Turkey, in Asia, for the last three years. Harpoot is situated at the elevation of 4,550 feet near the top of a small mountain range, in latitude 38° 20′ north, longitude 39° 20′ east. Twenty miles to south are the Taurus Mountains, from 6,000 to 7,500 feet high. Fifty miles north is the Anti-Taurus Range, with an elevation of 10,000 feet. The part of the United States which most resemble Harpoot in climate and in many physical features is Colorado.

The central fact of the climate of this part of the world is the long dry season. Around Harpoot it lasts from the middle of June to the middle of October, four months. During this time there are almost no clouds, the average relative humidity is under 50 per cent, and dew is never formed. The heat is not usually excessive, and during two-thirds of the time the wind blows from the north or northwest. Dur-

[1] On December 22, 1897, Professor Huntington wrote to the Chief of the Weather Bureau from Euphrates College, Harpoot, saying that he had lately come to that place from the United States and was keeping a meteorological record and would try to induce those at other mission stations, ten or twelve in number, to keep a simple record of weather and rainfall. It may, therefore, be assumed that the data given in the following Table 1 represents the observations made by himself at Euphrates College. Professor Huntington says that no observations of the barometer are included because he has only an aneroid. The mean maximum and mean minimum temperatures are not given because two sets of thermometers were broken in transit and a third is now in use. The records kindly sent to the Weather Bureau from Mersivan by Prof. J. J. Manissadjian for the years 1892–1896 will be found on page 245 of the MONTHLY WEATHER REVIEW for June, 1897. The Editor can but hope that Professor Huntington will succeed in obtaining equally good records from all the mission stations in Asia Minor, and thus contribute greatly to our knowledge of the meteorology of that region. Special efforts should be made to secure continuously recording thermographs and barographs for some of these stations, such as are sold by Richard Frères in Paris at a low price and can be easily transported.